DIGITAL COMPUTER
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OFFICE OF NAVAL RESEARCH · MATHEMATICAL SCIENCES DIVISION

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COMPUTERS AND DATA PROCESSORS, NORTH AMERICA

MANIAC III - UNIVERSITY OF CHICAGO, INSTITUTE FOR
COMPUTER RESEARCH - CHICAGO, ILLINOIS

Maniac III (see DCN, April 1960) has just been moved to its permanent location in the new computer building which is the home of The Institute for Computer Research.

The memory system, parts of which have been in existence for a long time, was immediately assembled. It is still lacking its reading amplifiers, and half of its core planes. The latter are being produced by a commercial manufacturer.

The arithmetic unit had all of its digital parts completed and tested while the computer was in its old quarters. All of the sequencing controls for both the numerical section and the address section have also been completed. Eight index instructions have been installed and tested. The arithmetic instructions are now being assembled.

The electronic circuits for the typewriter, tape punch, and photoelectric reader have been assembled. The instruction set which is associated with these machines is now under development.

The computer has been operated in the past from improvised power supplies, including storage batteries. The temporary system was kept intact during the move. The permanent supply is nearly finished, and will be placed in service when the computer is restored to operating status in its new quarters.

PERCEPTRON MARK I - CORNELL AERONAUTICAL LABORATORY -
BUFFALO, N.Y.

The Mark I perceptron—an experimental machine which can be trained to automatically identify objects or patterns such as letters of the alphabet—was demonstrated publicly for the first time in June at the Cornell Aeronautical Laboratory. The perceptron research program is under the sponsorship of the Information Systems Branch of the Office of Naval Research with the assistance of the Rome Air Development Center of the Air Research and Development Command.

The Mark I perceptron, a research device, is a limited capacity version of what eventually may become a family of efficient pattern recognizing machines. It was built to demonstrate and prove the feasibility of the basic perceptron concept which previously had been simulated on high-speed digital computers. CAL emphasized that their present equipment is intended for research purposes and has not been designed for particular applications. The Mark I is an electromechanical device consisting basically of a "sensory unit" of photo cells which views the pattern shown to the machine, "association units" which contain the machine's memory, and a "response unit" which visually displays the machine's pattern recognition response.

Dr. Frank Rosenblatt originated the perceptron theory and has been in charge of the program since it began in 1956. The 31-year-old research psychologist pointed out that the Mark I system can perform only the simplest pattern recognition tasks and is of scientific interest because of its use of new principles, rather than its present level of performance. The Mark I represents the simplest of the various types of theoretical models we are studying under the perceptron program. Perceptrons might eventually be used in many situations which now require human operators to differentiate between patterns. Such machines would be much larger than the Mark I, although constructed on the same principles. They would have a variety of sensory imputs. For example, they would be able to receive audio as well as visual inputs. They would also contain a greater number of association and response units and, consequently, would be able to perform much more complicated recognition tasks than the Mark I.

Considerable research and development effort lies ahead before perceptron-type machines are designed for such applications and it remains to be demonstrated that their use will prove economical, the CAL scientists noted. ONR and RADC are currently sponsoring a research program with the Aeronutronic Division of the Ford Motor Co., at Newport Beach, Calif., to simplify the design of perceptron association units by using small magnetic components.

During the demonstration, letters of the alphabet from a single type face were shown to the machine's photoelectric cell "eye" and it correctly identified the letters without error. The CAL scientists said that the recognition problem has been deliberately complicated in other experiments by adding letters of different type face and the machine had been correct 79% of the time.

The perceptron generally is taught to recognize patterns by an "error correction" training procedure. With this method, the machine's trainer places the test patterns in the view field of the perceptron's photo cell eye. When the machine incorrectly identifies a pattern, the trainer forces it to respond correctly by means of an electrical control. He does not influence the machine when it responds correctly. The number of pattern exposures and corrections required to develop maximum performance depend on the complexity of the pattern recognition task being attempted. It was noted that for the 26 letter recognition test, which had been demonstrated, the machine achieved an errorless level of performance after 40 exposures to each letter.

The scientists also noted that inadvertent errors on the part of the machine's trainer had little effect on the perceptron's ultimate efficiency. They have simulated the case of an "imperfect" trainer to determine what effect trainer errors might have. During the experiment, 30% trainer errors were deliberately introduced while teaching the machine to discriminate between the letters E and X which were placed at various arbitrary positions in the machine's field of view. For example, when shown an X the identification response of E was at times forced by the trainer. Following this training session, which was somewhat longer than normal, the machine surpassed its trainer's accuracy and was able to identify the test patterns without error.

The machine was also able to recognize partially obscured or distorted patterns. In experiments involving E - X discriminations, the letters were distorted by superimposing random dot patterns about their outlines. The tests indicated that although the maximum level of the machine's performance decreased it was still significantly above a chance level of performance.

The perceptron unlike some pattern recognition machines does not recognize forms by matching them against an inventory of stored images or by performing a mathematical analysis of characteristics. Recognition is direct and almost instantaneous since its memory is in the form of altered 'pathways' through the system rather than a coded representation of the unique stimuli.

In a simple perceptron, such as the Mark I, sensory units activated by the pattern transmit electrical signals to a set of association units. If the input signal to an A-unit is large enough, the unit becomes active and emits an output signal. The active A-units, in turn, transmit signals to the response units. The response units are two-state devices which emit one output if their input is positive and a different output if their input is negative. The output of an A-unit, a positive or negative voltage, is controlled by a "value storing device" in the A-unit. The settings of these value storing devices represent the memory of the perceptron. In training the perceptron, the object is to change the values of the set of A-units which characteristically respond to each stimulus so that the combination of their signals will have the proper sign (plus or minus). If the response obtained is correct, then the memory is not altered by the trainer. If the wrong response is obtained, however, the values of the active A-units are uniformly altered to correct the error. It has been proven mathematically that with a large enough perceptron such a procedure will always ultimately lead to the correct response for all stimuli to which the perceptron is exposed.

The Mark I perceptron employs conventional electromechanical devices. The machine's sensory unit, which translates the stimulus pattern into a discrete set of electrical signals, consists of a 20 x 20 square array of photo resistive cells mounted in a phenolic base plate. This plate is positioned in the film plane of a view camera.

The stimuli are white patterns such as letters on a black background, held in front of the camera. Each photo cell which received sufficient light from a stimulus actuates a transistor-driven relay which supplies "excitatory" and "inhibitory" signals along its 20 output connections. The signals are received by the machine's association units which also are transistor-driven relay circuits. The association units, or A-units, receive their input signals, over a random wiring network from the sensory units. Each association unit receives as its input the sum of a group of electrical signals from the sensory units. The A-units have a fixed threshold. When the input from the sensory unit exceeds this threshold the A-unit becomes active. Active A-units, in turn, supply output signals to the machine's response units. The amplitude of these signals is controlled by a memory device in each A-unit. The Mark I perceptron contains 512 association units.

The machine's response units are basically two-state devices consisting of a d-c amplifier driving a relay. The response unit's input is the sum of the signals from the association units to which it is connected. The response unit provides a visual indication of its state and also transmits a reinforcement signal to the A-units which are active. This reinforcement signal is stored by the memory devices in A-units to change the amplitude of their outputs. The Mark I perceptron has eight response units allowing for 256 possible responses. All may be employed when discrimination between several stimuli is desired. A single response unit is used when a simple either-or discrimination task is performed. However, it is anticipated that many more association units would be required to utilize fully all of the possible responses.

This ability to generalize from experience is one of several important perceptron features which set it apart from most other pattern recognition devices. After exposure to a limited sample of forms from a given class the perceptron is able to recognize other members of that class although it never has seen their particular images before. For example, having been exposed to a number of E's it can recognize an E similar, but not identical, to the ones it has previously seen. In addition, perceptrons are general purpose machines and each can be trained to perform any one of a wide variety of pattern recognition tasks.

Another unique perceptron attribute is that its design is based on a small number of statistical parameters, and some general logical constraints within which the actual connections can be drawn from a table of random numbers.

Dr. Rosenblatt originally conceived of the perceptron as a model of biological nerve net. The design of the perceptron now in operation is based on theoretical models which he believes to be consistent with current anatomical and physiological data including the latest assumptions about the number of neurons, logic of connections, degree of individual unit reliability, random variation in "wiring diagram", and type of signals employed in biological systems. On one point—the assumed "memory value" of the perceptron's association units—there is an assumption which does not have a clearly identifiable biological counterpart. He expressed the hope that continued improvement in the measurement of biological systems will lend support to this assumption.

Technical details of the research are available in the below listed Cornell Aeronautical Laboratory reports. The first three are presently available from the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. The two more recent reports will be released thru OTS during September.

Title	OTS No.	Price
The Perceptron, A Theory of Statistical Separability in Cognitive Systems, VG-1196-G-1; January 1958	PB 151247	$4.00
Two Theorems of Statistical Separability in the Perceptron, VG-1196-G-2; 1 September 1958	PB 151247-S	1.25

Title	OTS No.	Price
Perceptron Simulation Experiments, VG-1196-G-3; June 1959	PB 161065	$1.00
On the Convergence of Reinforcement Procedures in Simple Perceptrons, VG-1196-G-4; 15 February 1960	To be released	
Mark I Perceptron Operator's Manual, VG-1196-G-5; 15 February 1960	To be released	

The above reports should be ordered directly from OTS, with remittances made out to the Treasurer of the United States.

NCR 390 - THE NATIONAL CASH REGISTER COMPANY - DAYTON, OHIO

The National Cash Register's new Class 390 electronic data processing system is a solid state, magnetic core, fully transistorized processor that may be use . to handle all basic accounting functions. It consists of a central processor; a console; units to read punched paper tapes or punched cards used as input media; and auxiliary equipmen to create punched paper tape, punched cards, and control other peripheral equipment. The system is fully compatible with other processing machines, which permits integration into all existing data processing systems.

Two important features provide a low-cost system for general business use. The first is a unique magnetic ledger card that stores data in magnetic tape strips on the back of the form, yet carries all necessary printed information for reference and auditing on the front of the form. The second is a programmable printer capable of printing final results in any columnar arrangement on multiple forms and reports.

Central Processor and Console. The central processor has an external and internal memory. The external memory is data stored in machine language in magnetic ledgers, punched paper tape, or punched cards. The external memory is used to store detailed accounting information and programs. The internal memory is a magnetic-core consisting of 200 twelve-digit cells. The internal memory is used to accumulate totals during processing, and for storage of program instructions. The program is stored internally and may be modified at will by the monitor. The monitor may also extract information or insert new data or new instructions at any time without disturbing the computer program.

Input-Output. The System has four kinds of input: Punched paper tape, data stored on the magnetic ledger cards, punched cards, and operator entry via the console keyboard. All four of these methods may be used simultaneously. There are also four methods of output: Print-out on reports or multiple-copy hard-copy records, punched paper tape, punched cards, and output to magnetically-encoded ledger cards. Three of these output methods may be used simultaneously, the only limitation being that cards and tape may not be used at the same time.

The console has a full-amount keyboard through which data or program instructions may be set up and audited visually, and then entered directly into the memory units under control of the program. This feature permits entering one-time programs and provides a simple way for the monitor to correct errors which the processor detects.

Printer. The printer does in one operation what would require three or four separate runs on other processors. The printer and its continuous-form feeding device may be programmed to print in any columnar arrangement on multiple-copy forms, on related accounting forms, and on reports. For example, in a payroll application, five fundamental records are needed: checks, pay statements, earnings records, a payroll journal, and a check register. Processing these related records in one simultaneous operation assures that all records and

processed data are identical. When one set of records is in balance, all records are in balance.

Magnetic Ledger Card. The magnetic ledger card is an exclusive feature of the System. This card combines human language and machine language on the same record. Records of totals, balances, rates, and other figures about the account are printed on the front of the ledger card, and the same information is stored in strips of magnetic tape on the back of the form. The magnetic ledger card thus combines the advantages of detailed historical ledger records, and the speed, flexibility, and storage capacity of magnetic tapes. A magnetic reading device is built into the printer. In less than two seconds the reading device automatically aligns the magnetic ledger to the proper position, reads and verifies about 200 characters of encoded information, and electronically verifies that the correct ledger is in the printer.

The file of ledger cards is easily removed. Specific accounts may be interrogated without interrupting the monitor or the operation of the processor. The ledger cards are always available for random-access posting or for random-access inquiry. By furnishing a printed historical record, the magnetic ledger cards perform an important function not available before in a low-cost system. Each time an account is processed, the totals and balances affected are updated in both human language and encoded machine language. The electronic encoding on a particular ledger card may actually interrogate the central processor and modify the program according to the requirements of the specific account.

As an input medium, the magnetic ledger is valuable for creating automatic trial balances, statistical analyses, and management reports. After a program has been encoded in machine language, it is placed in a permanent program file, where it becomes a program storage card. An installation would have a file of these programs for each of the various applications being processed. The memory can be reprogrammed in a matter of seconds simply by entering a different set of instructions from the program file. The 390 is then ready to handle a different application.

Other Input and Output. Punched cards can be used as input for program instructions or data to be processed. Punched card output can be produced for integration into other systems, for further processing on the 390, or for creating documents such as bills or checks which are to be used as input when they are returned to the business.

Large volumes of data may be fed into the system by punched paper tape originated as a by-product of operations on an accounting machine, an adding machine, a cash register or other miscellaneous tape-punching device. Or the punched tape might have been produced on the 390 itself. The logic structure has been specifically designed for paper-tape sorting because of the requirements of business systems. Punched tape produced as a by-product of other accounting functions can be processed without converting it to other types of media. The 390 has the ability to read a reel of paper tape from beginning to end, then automatically rewind the tape and read it again. In successive passes of the tape, the processor can automatically modify its own program to select the range of accounts or classifications it will process.

Programming. The System is specifically designed with internal logic which provides relative simplicity and economy in programming by means of a four-address system.   A relatively small memory capacity can perform in one command, jobs that might require four, five, or six commands and memory-cell locations in other single address data processing systems. After the narrative instructions for an application are written, these instructions are translated into machine language and each step of the program is represented by a 12-digit command written as decimal digits. There is no necessity of converting from decimals to another numbering base to provide commands or data to the central processor. This means the 390 can be programmed in the same language the machine operates on. At any processing point the actual command being executed is displayed in lights, and can be compared to the original program if examination is needed. The 12-digit command number is recognized by the processor as separate digital addresses and modifiers. For example, the following four-address command is a complete arithmetic sentence written in format understandable to individuals with only a minimum amount of technical training:

08-00-01-98-99-07

The "08" is the command. The "00" modifies the command instruction to select memory planes. The remainder of the instructions of this particular command tell the machine to add the contents of memory-cells 01 through 98, put the grand total in memory-cell 99, and then proceed to memory-cell 07 for its next command instruction. Note that the processor is not confined to the use of consecutive memory locations. The ability to exit from a particular command to any desired location to obtain the next instruction provides unusual flexibility and simplicity in programming.

PB250 - PACKARD BELL COMPUTER CORPORATION - LOS ANGELES, CALIFORNIA

Over the past five years general purpose digital computers have developed in size, speed, and flexibility, but this development has been concentrated in the field of large-scale computers, while medium and small computers have shown little change. A glance at a comparative chart of these latter computers would show that, aside from the appearance of transistorized devices, no significant change has occured except, perhaps, that more recent computers are more costly. The result is a comparative de-emphasis on small and medium-sized computers, with a growing tendency to large-scale centralized computing. Two things required if this trend is to be reversed are less expensive small computers, and computers which can better compete on cost-per-unit-answer with large-scale machines.

The PB 250 is the first computer with both of these characteristics. Costing only $30,000, it can compete with large-scale machines in speed and flexibility. Up to 40,000 operations can be performed each second. Add time is 12 microseconds, multiply requires 276 microseconds, while divide and square root each takes 252 microseconds. Further, the last three operations are variable in execution time, depending upon the length of the terms. The quoted times are for a word consisting of 21 bits and sign. Floating point operations with a 37-bit mantissa and a 7-bit characteristic require less than three milliseconds.

In addition to the speed with which arithmetic operations can be performed, the overall speed is also a function of a rich command structure. 46 commands include double-precision operations, block transfer, Gray to binary conversion, and an elaborate input-output system. Cost-per-unit answer depends upon programming ease as well as computing speed. The computer is provided with a symbolic programming system employing mnemonic instruction codes and a variety of subroutines.

An additional cost factor that often has made small computers impractical is that of expanding the memory. Magnetostrictive lines are used, which together with their associated circuitry, are mounted on plug-in etched modules. The memory can be inexpensively expanded to 16,000 words by the addition of these modules, and, further, these can be fast access as well as bulk storage lines. 16,000 words of core storage also can be added externally. All memory operations are parity checked.

Both input and output information can be processed while computation proceeds. Standard input includes an alphanumeric typewriter, a paper-tape punch and reader, high-speed (2 megacycle) block input and output, 32 control outputs and 30 control inputs. The latter provides a means for controlling a wide range of peripheral equipment and other devices. High-speed paper tape equipment and up to six magnetic tape handlers are optional equipment. The magnetic tapes employ the IBM 700 series tape format, although any code using up to eight channels can be employed.

A radically new feature is its ability to operate in tandem with another computer as an input-output processor. When this other computer is another PB 250, the two computers operate as a single synchronous system. This separation of input-output processing from central computing results in a very powerful system, one that up to now has only been available in very large and expensive computing systems. Further, the two PB 250's can be employed separately when input-output requirements are not excessive.

Punched card equipment will be available in the near future. Standard Packard Bell Computer Corporation Multiverters are available as analog-to-digital and digital-to-analog converters.

The speed and flexibility of the input-output system permits it to function as a univer-
format-to-format converter. The cost of such converters has been prohibitive up to now,
without complete universality. The computer, because it is general purpose, can perform
any transformation between formats and media, and perform a variety of editing and arithmetic
operations in the process.

The final cost to be considered in the operation of a computer is in maintenance. The
unit is completely solid state and uses only 350 transistors. Furthermore, it is the first com-
mercial computer to be completely modularized. 145 cards, together with a plug-in
magnetically-regulated power supply and a Flexowriter, make up the entire computer. The
computer is 30" x 19" x 24". Low density packaging has been used to assure a long life and
high reliability; approximately 25% of the module spaces are not employed in the basic com-
puter. The computer proper requires 30 watts and 2 voltages. A rack-mounted version,
using 31-1/2" of a standard 19" relay rack, permits easy integration of the computer into a
wide variety of on-line and off-line computing systems.

UNIVAC III - REMINGTON RAND UNIVAC - NEW YORK, N. Y.

The Univac III computer system, newest addition to its line of large-scale electronic com-
puters, was announced by the Remington Rand Division of Sperry Rand Corp. A "solid state"
computer, it was described as having a processing speed nine times faster than its predecessor,
Univac II, and offering a 25% increase in operating efficiency over present data processing sys-
tems. The general purpose data processing system, featuring high performance at medium
cost, is another advance in the design, development, and construction of modern computing
mechanisms. A powerful instruction repertoire was created by fitting reliable solid-state
circuitry to the specifications of advanced logical design. Modularity allows the capacity of
the system to be expanded smoothly and efficiently by the addition of compatible components.
This versatility encourages the user to choose a system that will satisfy his present process-
ing needs at the most reasonable job cost. At the same time, he is assured of having a system
that can grow with his needs.

Features. Automatic program interrupt provides a means for optimizing the use of input-
output units. All input-output operations are controlled and buffered through synchronizers.
Microsecond internal processing speeds are those usually associated with computing systems
designed for engineering and scientific applications. As an example, add time is 9 micro-
seconds for single precision operands. Another 4-1/2 microseconds is added for each addi-
tional word. Fast access core storage is available in multiples of 8,192 words, yielding a
memory size of 8,192, 16,384, 24,567 or 32,768 words. These dimensions enable the system
to process large segments of an application in a single operation.

There is a comprehensive single-address instruction repertoire, including powerful pro-
gramming logic, automatic index register modification, multiple short word operands, field
selection, and both decimal and binary arithmetic. Reading and writing of magnetic tape,
reading and punching of cards, and printing, are all overlapped with computing. A compiler
accepts as its input Basic COBOL (Common Business-Oriented Language). (COBOL is a con-
cise form of the English language designed for the statement of business and Government
agency problems.)

Basically a "bit machine," the UNIVAC III can be programmed to perform many types of
special manipulations. This ability allows the programmer to use exceedingly sophisticated
programming. Bit manipulation also allows the system to utilize a variety of input-output
codes.

Input-output Devices. The basic configuration with a pair of data communication channels,
and associated power, control and switching circuitry can effectively employ as many as 16
UNISERVO III tape handling units. Each channel pair consists of a write-channel, which con-
tains the circuitry for recording and also for check-reading, and a read channel. Each
UNISERVO may read data from tape moving either forward or backward, write on tape moving
forward, and rewind its tape. Another pair of channels, which operate in an identical

manner, can be added to the central processor to integrate another 16 UNISERVO units into the system. The UNISERVO III units achieve increased reliability by incorporating a check-read head and circuitry to automatically read information as it is written, thus minimizing the possibility of producing an unreadable output tape. If, during a writing operation, verification is not obtained, a bad spot pattern is generated until proper verification of the pattern indicates that the bad spot has passed. The unit reads and writes at the rate of 100 inches per second, 1,000 frames per inch, with each frame consisting of 9 bits (8 plus parity). This is an effective rate of 200 kc of numeric information or 133 kc of alphanumeric information.

Other input-output devices include:

UNIVAC compatible tape utilizing the UNISERVO II
Punched card reader   700 cards per minute
Card punch   300 cards per minute
High speed printer   700 lines per minute - full alphanumeric capability
Card punching-printer   150 cards per minute - full alphanumeric printing
                                                   on both sides of card

Word Size. The word consists of sign, 24 information bits, and 2 parity bits, making a 27 bit word. This word can be programmed as a pure binary, 4-six bit alphanumerics, or 6-four bit numerics. An instruction can operate as 1 to 4 words.

Error Detection - Central Processor. Two parity bit positions of the basic UNIVAC III word are used to check data transfers and arithmetic operations for accuracy. Congruence arithmetic is employed using the number 3 as a modulus. The principles underlying the checking methods are the same as those upon which the familiar "casting out of elevens" is based. In these cases where the parity bits alone are insufficient for thorough checking, special circuitry is included to greatly reduce the likelihood of undetected failures. Error detection causes an automatic program interrupt.

Summary.

Memory cycle time 4.5 microseconds
Memory size 8,192 to 32,678 words
Four arithmetic registers
Seven to 15 index registers
Multiple precision arithmetic
Standard Excess 3 UNIVAC language or any other language may be used for input-output operations.
Scatter read-write from tapes
Single address instructions containing 4 bit index register, 6 bit operation code, 4 bit modifier, and a 10 bit memory address.
Indirect addressing
Field select utilizes a special instruction word
Rental for a typical installation $17,500 per month
May use tape units of other manufacturers
Floating point available
Utilizes UNIVAC LARC circuitry
RANDEX drum available

Installation. All cables connecting input-output equipment and tape units with the processor can enter the processor modules at the floor level or from underneath in the case of a sub-floor. All units are independently air cooled with air intake at the floor level and exhaust at the top. Power supply lines are 3 phase, 60 cycle, 208/120 volt, 4-wire grounded neutral. Tolerances on 120 volt lines are 100-130 volts, 59.5 to 60.5 cycles. Recommended room size for a large installation is 43 ft. by 43 ft. by 12 ft. high with 40 tons of refrigeration, including room requirements.

COMPUTING CENTERS

MATHEMATICAL SERVICES LABORATORY - AIR PROVING GROUND CENTER - EGLIN AIR FORCE BASE, FLORIDA

The 1103 Univac Scientific Computer (Serial Number 2) was phased out of operation 15 April 1960 after supporting computational requirements since early 1955 on many Air Force Research and Development projects such as: B-58 Aircraft Fire Control System Evaluation, Bomb Ballistic Tables, M-1 Toss Bomb Computer Evaluation, Crosswind Ballistics, and Satellite Position Computations. The peripheral equipment associated with the 1103 will be retained and utilized on the 1103A Univac Scientific now being installed at Elgin AFB. Details of the 1103A applications will appear in future Newsletter articles.

A 7090 Electronic Data Processing System will be shipped to Elgin during the first week in December 1960 with a final checkout on 24 January 1961. It will replace the presently assigned 704. Operation of the 7090 will be through FAP and Fortran under control of the Fortran "load and go" monitor system.

AERODYNAMICS LABORATORY - DAVID TAYLOR MODEL BASIN - WASHINGTON 2, D. C.

A technique has been worked out by the Aerodynamics Laboratory of the Navy's David Taylor Model Basin to simulate the launching and subsequent flight of both a host aircraft and a missile ejected from it. The technique links a transonic wind tunnel, to determine initial data including interference effects, with an Alwas III-E digital computer to "fly" both the aircraft and missile and predict their behavior during and after separation of the missile from the aircraft. The wind-tunnel data are reduced by the computer and used to predict the next trajectory point. These results are then fed back to the wind tunnel, and the process is repeated to obtain a complete "trajectory," point by point.

The computer prediction uses the equations of motion for aerodynamic bodies with 6 degrees of freedom. All physical characteristics, including damping and inertia derivatives, thrust, control effects, and most any other pertinent condition can be accounted for in the computer program. This technique gives final results for a "trajectory" in as little time as two hours. A specific number of trajectories can be completed about four times as fast as previous grid methods of wind-tunnel testing followed by separate data reduction. A combination of the two methods has been recommended as being best. David Taylor Model Basin Aero Report #970 has been published giving the general details of the technique.

COMPUTER & MATHEMATICAL SCIENCES LABORATORY - L. G. HANSCOM FIELD - BEDFORD, MASS.

A new 3-color display oscilloscope was added to the AFCRC Magnetic Computer (see DCN, January 1959) in January 1960 and has been in use since this time. The display has proven valuable on several Laboratory projects and will undoubtedly find many additional applications in the future. The color tube is a standard RCA 21 inch, 3-gun tube used in color television sets, and deflection is controlled by low-impedence coils driven by high-current analog circuitry. Digital deflection information is available from the computer's 20 bit output register, of which 8 bits are used for each x and y deflection, and 1 bit is used for controlling each of the 3 color guns. A transistorized digital-to-analog converter was designed and constructed by AFCRC personnel to drive the deflection circuitry from the computer's output register.

A computer instruction is used to send deflection and color information to the output register and initiate the display of a point. Points may be displayed at the rate of 7700 per second, or at any slower rate, since a point continues to be displayed until it is replaced by a new one. Each point must be retraced about every 1/30 of a second or more often, otherwise

flicker becomes noticeable. About 250 points displayed at maximum computer speed seems to be the nominal operating limit.

Primary colors or red, blue, and green are used, and in theory two or more colors could be combined to produce a total of seven different colors including white; however, limitations in the present color convergence circuits preclude this. The colors are valuable in identifying and observing several simultaneous outputs. For instance, in processing data dealing with signal waveforms, it is convenient to display the input and output curves in two different colors, or in mathematical computation, to display families of curves in different colors. Quite often, one of the colors is used to present an x-y axis. This produces a reference which is free from parallax, gain variation, and drift; and is subject only to convergence error.

AEC COMPUTING AND APPLIED MATHEMATICS CENTER - NEW YORK UNIVERSITY - NEW YORK, N.Y.

The camera in the CRT unit in the IBM-704 is being modified by Brookhaven National Laboratory because the IBM camera takes a "double frame" instead of a movie shaped frame. In addition, the friction drive in the IBM system does not match the holes in the film with the pictures. Brookhaven is incorporating a Flight Research Model III-B 16mm movie camera in a special mount so that this camera can replace the IBM camera without major modification. The new system will be checked out shortly.

NEW COMPUTER CENTER - UNIVERSITY OF SOUTHERN CALIFORNIA - LOS ANGELES, CALIFORNIA

The University of Southern California has announced the establishment of a 2 million dollar Computer Center for Education and Research. Two of the nation's leading designers and manufacturers of data processing equipment—Remington Rand and Minneapolis-Honeywell—will install their modern high-speed computers on the USC campus.

A Univac Solid State 80 with magnetic tape units will be placed in the Center by Remington Rand this fall. Also, a complete line of 90 column punched card equipment, including a Univac 120 electronic computer and a model 330 electronic punch card calculator has been installed.

A Honeywell 800 electronic data processing system including a central processor, tape control, magnetic tape transports, printer-card reader-card punch control, high speed printer, card reader and card punch will be installed in June 1961.

Formation of this Center at a private university with the complete cooperation of two private business firms marks a new milestone in joint enterprises between industry and education. Both companies will also train employees at the Center, house their students in campus dormitories, and have them eat in the University Commons.

USC professors and graduate students in business, engineering, medicine, and the physical and social sciences will be given one 8-hour shift a day, Mondays through Fridays, on both computers to conduct their scientific research projects. In addition, the Center will permit USC to expand its existing classes in the use of computers and establish new ones. Each company will cooperate with the University in new research projects in the rapidly-expanding field of computer science, seeking new uses for computers and working on designs to improve existing equipment. Company teachers will be available to lecture to USC students, and University faculty members will likewise be able to meet with company classes.

USC has purchased a 13,000-square foot building at 1010 West Jefferson Boulevard, the northwest corner of the campus, to house the Computer Center, and will take possession July 1.

NEW COMPUTER CENTER - U.S. NAVAL POSTGRADUATE SCHOOL - MONTEREY, CALIFORNIA

On 8 January 1960, the U. S. Naval Postgraduate School Computer Center was formally established. The functions of the Center are to provide: (a) Instructional laboratory services to meet scheduled computer courses laboratory requirements. (b) Computational services to NAVWEP for weather analysis and production of weather forecast schedules. (c) General computational services to the U. S. Naval Postgraduate School faculty, students, and NAVWEP research activities.

The Control Data Corporation CDC-1604 computer (see DCN, January 1960) was delivered to USNPGS on 5 January 1960. There are 4 tape drives, photo-electric reader, teletype punch, monitoring typewriter, and display console. Off line to the 1604 are the IBM 757, 727, and 717 Printer.

The National Cash Register NCR-102A computer (acquired June 1954) has on-line two IBM 523's (card reader and card punch) two magnetic tape drives, point plotter, Flexowriter, and console. Off line to the NCR-102A is the IBM 402.

For program preparation there are four Flexowriters and three IBM card punches.

Almost immediately following acceptance of the 1604 (approximately 20 January 1960) at the U. S. Naval Postgraduate School, this computer was being used one shift per day. Approximately three months later the use time had extended to at least 12 hours per day. The overall performance of this computer has been exceptionally good and this is indeed commendable in view of the fact that USNPGS received the first model 1604 built by Control Data Corporation.

The NCR-102A is now obsolete, however, it is currently operating at least 20 hours per day, 7 days per week.

DIGITAL COMPUTER DIVISION - U.S. NAVAL ORDNANCE LABORATORY - CORONA, CALIFORNIA

Burroughs 205. The system presently in use at NOLC is composed of the following components: central computer with floating point, cardatron (for buffering and editing) with two input and three output units, 50 bin Datafile, and three Datareader magnetic tape units. The system is operated as a card-in/card-out system with the magnetic tape serving as auxiliary data storage. The Datafile serves mainly as a program library storage unit. The computer is used primarily for processing data relating to missile production, testing, and firing. A large information storage and retrieval systems is in operation on several types of missiles. Information in the file consists of complete missile life history data from production acceptance, throughout service life testing, to final firing. Routine summary reports are processed as well as one-shot special requests. The present computer is being operated on a 24 hour, 7 day basis. Additional rental time is available as required at several nearby 205 installations.

IBM 7070. Approval has been received for the rental of an IBM 7070 to replace the existing overburdened Burroughs 205 computer. Delivery is scheduled for November 1960. Preparations for necessary programming and installation are being actively pursued. Within the limitations imposed by the hardware on order the 7070 will be operated as a tape oriented system.

COMPUTATION CENTER - U.S. NAVAL WEAPONS LABORATORY - DAHLGREN, VIRGINIA

New NORC Memory. The 20,000 word core memory built by Daystrom Instrument for the NORC was installed in March 1960, replacing the original 2,000 word CRT memory. The reduction in maintenance and error stops brought about by the new memory has netted about one extra hour of useful time out of each 24.

<u>UDT (Universal Data Transcriber)</u>. The UDT has been mentioned in this Newsletter at several stages in its development; it is now possible to describe some of the applications in which it has been usefully employed. Briefly, the UDT is a stored-program device of computer-like logical structure. Supplementing the standard set of instructions is a plug-board on which special instructions can be composed. Transistor internal circuitry operates at a megacycle pulse rate. The random-access memory of 8192 eight-bit characters serves both for instructions and for data.

Nearly all the applications thus far have involved NORC tape either as output from or input to the UDT. Using NORC tape as input, the following conversions have been performed:

1. To Remington Rand punched cards (speed 100 cards per minute, punch-limited).

Punching checked at reading station following the punching station.

Equipment for punching of IBM cards is also on hand.

2. To punched paper tape (speed 60 characters per second, punch limited).

This tape is used for transmittal of computed results via teletype.

Using NORC as output, the following conversions have been performed:

1. From punched cards, both Remington Rand and IBM (average speed about 300 cards per minute). Reading is checked at second reading station.

2. From punched paper tape (speed 300 characters per second, limited by tape reader).

3. From IBM-709 tape (average speed about 240 characters per second).

4. From analog tape. An analog-to-digital converter and a limited amount of tape channel demodulation equipment is included in the system.

'One further applications helps to indicate the extreme flexibility of the UDT. In testing a system being considered for telephone line transmission of data, the UDT was used to inject a systematic train of pulses into the transmission device which transmitted into a loop circuit to a receiver located in the same room. The pulses returning through the receiver were fed back into the UDT, which detected and counted the errors arising in transmission.

COMPUTERS AND CENTERS, OVERSEAS

FRENCH TO ENGLISH TRANSLATION - BIRKBECK COLLEGE, DEPARTMENT OF NUMERICAL AUTOMATION, UNIVERSITY OF LONDON - LONDON, ENGLAND

Two of the M. 2. computers have now left this Laboratory and a third is in course of commissioning.

Work in the Laboratory is at present concentrated on two major programming exercises. The first is a revision and re-writing of the machine translation programmes for French to English, originally constructed for the APEXC (see DCN, April 1957) and MAC computers, for the large University machine Mercury. In the course of the re-writing a number of extensions to the original grammatical processing involved in the programme have been added and a subsidiary programme has been written to enable the machine to assist a human operator in up-dating its own dictionary. In essence the dictionary up-dating programme does the following things: when presented with a text in the foreign language, each text word is compared with the existing dictionary. If a text work is directly derivable from the dictionary either as a whole entry or as a valid stem-ending decomposition, a statistical count of this fact is made in

the dictionary itself and the next word of text is read in. When a text word is encountered which cannot be found in the dictionary either as a whole or as a valid decomposition into stem and ending, the machine stops and types out an indication to the human operator that attention is needed. The human operator then inserts the appropriate stem and any indication as to ending structure which is needed, together with context numbers to deal with ambiguities and idioms. Having absorbed this information and inserted the new entry in an appropriate place between existing entries, the machine proceeds to process text as before. It was felt worth writing this programme because after the first two thousand words of French dictionary had been compiled by hand, it was found increasingly difficult with a given text to find new words. This stems from the fact that human operators have limited memory facilities for words already contained in their partially constructed dictionary.

The second main line of study consists in the programming of various information processing operations typified by the construction of glossaries, concordances and syntactic analyses of text. A concordance and glossary have been made for the Old English text of Orosius by King Alfred, which consists of about 60,000 words. This took seven hours of computing time and approximately three weeks of human operating time in typing and checking the original tapes. The output typing time of the machine tape was approximately eight hours.

A third direction in which increasing effort is now being expended is the writing of a linguistic autocode which it is hoped will enable linguists to programme their own operations for a computer. Two lines of approach are being developed to this problem. In the first a repertory of up to 256 sentences of use to linguists is being constructed, a typical example being "Make a glossary from the given text", and a more exotic example, which it is hoped eventually to include will be "Translate the input text into languages x, y, z, ... w." The second approach is the development of an autocode which will accept linquistic definitions or statements of the type "Search list A for stem of text word." This is more in line with the type of autocode used by mathematicians and business men when using a computer, but it remains to be seen whether a set of definitions whose meanings is sufficiently clear to linguists can be prepared, and a field investigation of this problem is at the moment under way.

COMPUTER LITERATURE INDEX - FERRANTI, LTD. - LONDON, ENGLAND

Ferranti has issued a comprehensive 17 page listing of Ferranti literature under the title "Classified Index of Computer Literature" (List CS 261). Copies may be obtained by writing to Ferranti, Ltd., Computer Department, 21 Portland Place, London W.1., England.

1301 SYSTEM - INTERNATIONAL COMPUTERS AND TABULATORS LTD. - LONDON, ENGLAND

An new transistorized electronic business computer of advanced design has been announced by International Computers and Tabulators Ltd. The 1301 is a product of the combined experience and technical knowledge of International Computers and Tabulators Ltd. and The General Electric Co. Ltd. of England. In the design and development of the 1301 the two companies have made successful use of their jointly owned design and co-ordinating group, Computer Developments Ltd. The system is suitable for a wide range of industrial and commerical organizations, from those requiring a punched-card data processing system capable of very high operating speeds to those requiring a fully integrated high-speed magnetic tape system. A salient feature is that it is possible to increase the size or the operating speed of the basic machine as originally installed to meet the data processing needs of a growing company. Design emphasis has been to provide a machine which, although large and of exceptional speed and capacity, is simple to operate and simple to program.

The basic machine uses 80-column punched cards and incorporates a card reader, a line printer, card punch, a core store with a capacity of 400 words, and a rotary magnetic drum store with a capacity of 12,000 words. Furthermore, the core store can be increased to

2,000 words in steps of 400, while the drum storage can be increased, by the addition of seven more drums, to no fewer than 96,000 words.

Up to eight magnetic tape transport units can also be added to the machine, and for this purpose two tape systems are available: standard, with an input feed rate of 22,500 decimal digits a second; and high performance, with a feed rate of 90,000 decimal digits a second.

A single address system of programming is used and a comprehensive auto-code is available. Time sharing can be used extensively, especially during input and output.

The fully transistorized 1301 operates at the high pulse rate of 1 Megacycle and the wrapped connection technique of joining wires is used throughout. All the related equipment is entirely under the control of the program and neither costly buffers nor plug boards are required. The basic computer can be accommodated in a room of 500 sq. ft. and imposes a maximum floor loading of 100 lb. sq. ft. It requires a three-phase mains supply with a range of 246/440 volts. Because of the use of transistors intead of valves, it dissipates only about 4 KW in heat, and special cooling arrangements or air conditioning are not normally required, although air conditioning is advisable when magnetic tape units are included in the system.

Data Storage. The word length is 12 decimal digits, alphabetical characters being represented by two digits. As stated above, the minimum immediate-access magnetic core store of 400 words can be increased to 2,000 in steps of 400. Each rotary magnetic drum holds 12,000 words in 60 peripheral channels each of 200 words, each channel being divided into 20 decades of 10 words. Transfers to or from the drum may be in either decades or channels, and any number of decades up to 20 can be transferred in one instruction. The magnetic drum rotates at 5,240 r.p.m. and rapid average access time for a decade transfer is 5.7 milliseconds, to which must be added 0.57 milliseconds for the actual transfer. A channel transfer takes a maximum of 12 milliseconds. Decades and channels are numbered from zero upwards regardless of the number of drums, and transfers are not affected if a decade transfer should involve different drums. Besides the 12,000 words in 60 channels on each drum, two "reserve" channels of 200 words each are used to hold special programs such as engineering test routines. Information can be read from these channels as from the others, but they are protected from being overwritten except during manual intervention by the test engineer.

Arithmetic Unit. The computer operates in a serial-parallel code. The fast arithmetic unit consists basically of 3 one-word registers "A, B, and C" which are connected individually and through what is colloquially termed "the mill", in which all numeric processes take place. Register A is used as the link between the core store and the arithmetic unit, and is also connected with the program controller. Arithmetic and logical operations normally use Register B, which is also used for output to the printer and punch. Results of functions using Register B may either be left in Register B or placed in the core store. The program is obeyed sequentially from the core store. One word normally holds two instructions and as each word is transferred to the program controller via Register A, the function of the more significant half of the word is obeyed, followed by the least significant half. The transfer of each pair of instructions from the program controller takes 12 microseconds. Some typical times are:

Addition - leaving result in Register B	21 microseconds		
Addition - leaving result in core store	25	"	
Logical operation	21	"	
Test	12	"	
Multiplication - per digit in the multiplier	170	"	average

The arithmetic unit will operate automatically in decimal or sterling, the pence position being variable within each individual word.

The newly designed card reader operates at a speed of 600 cards a minute; apart from the actual sensing unit, it consists only of a decoding device. Cards are fed endwise, face down, column 80 leading, and pass two sets of photo-electric cells (three columns apart) in moving from magazine to receiver. The magazine holds up to 2,000 cards. There are two receivers, one with a capacity of 2,000 cards and the other 500 cards, and the selection of receiver is

under program control. The first set of photo-electric cells encountered by the cards are the reading cells and the second set the check-reading cells. Register C is used as the input register and is loaded with the zone and numeric components of three columns from each set of cells. The comparison of readings from the two sensing stations is carried out by program.

Line Printer. The line printer operates at speeds up to 600 lines a minute, there being 120 print positions per line and 50 characters per print position. Characters are spaced at 10 to the inch horizontally and six to the inch vertically. Each print position has its own "wheel" of 50 characters, and 120 of these wheels are bonded together to form a printing "barrel" which rotates continuously at 800 r.p.m. Printing is controlled entirely by program, and pulses are sent to the required print positions as each character passes the hammers. These pulses are sent to the line printer direct from Register B, and a check is carried out by program, and, by using indicators set by the printer, ensures that pulses have been sent at the correct time. Paper throwing is also controlled by program. When throwing at full speed the paper travels at 2.1 milliseconds per line. A sheet marker ensures the correct positioning of each new form to be printed. The printing speeds depend on the type of job being processed, but, as an example, direct listing from cards is carried out at 570 fully printed lines a minute.

Card Punch. Cards are punched at the rate of 100 a minute, pulses being sent from register B to the punch knives in the same way as for the printer. The punching is read back into the computer by means of a reading station, and checking of the information actually punched is carried out by program. The punch magazine holds 800 cards and the receiver 650. Cards may be offset in the receiver by program.

Magnetic Tape. The magnetic tape facilities on the computer require the addition of a magnetic tape control unit and up to eight tape transports. There are two types available, High Speed and Standard. Although tape may be read and written simultaneously, only one operation of each kind can be carried out at the same time. Transfer of data from tape to core store and from core store to tape is effected by an automatic interrupt facility. As each word is read from the tape, the tape unit requires access to the computer, and the program currently being obeyed is interrupted while this occurs. When writing, the program is interrupted when a word is ready to be put on to tape. Each tape transport may be individually numbered for reference by the computer. A queuing system operates whereby, when processing a large file of data, any two successive reels of the file may be placed on two different transports; the transports are assigned the same number, and the "Operate" button is pressed on each transport in the required sequence. Upon starting the job, reel 1 will be processed and, as soon as the re-wind order is given for that reel, work will begin on reel 2. Thus, while reel 2 is being processed, reel 1 can be re-wound and replaced with reel 3. The reel length is 3,600 feet and the block length is variable.

When writing, information put on to tape is immediately read back for checking. A powerful system of checking ensures that when tape is read, any single bit error is automatically corrected and any double bit errors detected for each lateral position or "Frame" across the tape. In the vast majority of instances there is no loss of time, and no programming effort is required. These conditions apply to both of the two alternative magnetic tape systems.

The High Speed Tape System. With this system the automatic interrupt facility stops the program for 15 microseconds every 133 microseconds. The tape is 1 inch wide with 16 tracks. Packing density is 600 decimal digits to the inch and the tape speed is 150 in./secs., giving a rate of 90,000 decimal digits a second. A last re-wind of 225 in./sec. is provided. The stop time is 2.9 milliseconds, the start time 3.2 milliseconds, and the inter-block gap when the tape is stop-started when writing is 0.935 inches. If a read or write order is given within 0.533 milliseconds of the completion of a block, continuous processing will be maintained: then the inter-block gap on writing is reduced to 0.7 in. When reading, the tape may be stop-started in the minimum gap of 0.7 in.

The Standard Tape System. With this system the automatic interrupt facility interrupts the program for 15 microseconds every 533 microseconds. The tape is 0.5 in. wide with 10 tracks, giving a rate of 22,500 decimal digits a second. In all other respects this system is compatible with the High Speed System.

Programming. A single address system is used, with a comprehensive range of functions including some special functions connected with the input-output units. Two digits are used for the function and four for the address, thus two instructions may generally be held in each word. The exceptions are drum transfer and magnetic tape read-and-write instructions which are double length and occupy one word each.

A large range of testable indicators are available, and these may be divided into four main groups: (1) Those set by program. (2) Those set by manual switches on the control console. (3) Those set to record the state of numbers leaving the arithmetic unit. (4) Those set by various conditions in the related units.

The programs are normally written in blocks, which are convenient sections of the whole routine. Each block is assigned a number which is used as a relative address. It is therefore easy for different programmers to write different sections of the routine, merely referring to data or instructions in another block by the appropriate relative address. The various sections of program, when completed, are punched into cards, as are the relative addresses. When all the cards have been punched the whole pack is fed into the machine, and, by means of a special program stored on one of the reserve channels of the drum, all the relative addresses are translated into absolute addresses, the results are stored on the drum, and the computer is then ready to start the program. Because of the operating principle of the program controller, the problem of incorporating a sub-routine in a main program is very straight forward; the program controller provides the link which will return control to the main program either to the next instruction or to any other desired point.

A large variety of sub-routines are available, including, in particular, programs for operating the related equipment. By using the technique of time-sharing, the card reader, card punch, line printer, and magnetic tape units are made to operate simultaneously. Alternatively, the main program may be time-shared with, for example, the operation of the printer and punch, or any other combination. This permits the high internal processing speed to be utilized at all times.

UTECOM LABORATORY - UNIVERSITY OF NEW SOUTH WALES - KENSINGTON, AUSTRALIA

The UTECOM computer laboratory has been in existence since September 1956, and is built around an English Electric DEUCE computer, fitted for 64 column operation. It is one of some 30 DEUCE machines now in existence throughout the world. The laboratory offers scientific computing and data processing to outside industry and other Universities in Australia as well as doing jobs within our own University. In addition, almost all State Government Departments who require the use of a large computer operate through UTECOM. It has been estimated that this laboratory is now coping with by far the major portion of scientific and industrial computer work in Australia. The programme library facilities are by far the largest in Australia. At present the machine is used on an average of over 12 hours a day, seven days a week.

Some of the more unusual problems recently treated have included:

1. A study of the economic structure of Australia (this is probably the largest single calculation done on a computer in Australia) and involved inversions of 119 x 119 matrices for the Department of Applied Economics, Canberra University College, Canberra, A.C.T.

2. The estimation of T.V. and radio audiences for all channels and stations throughout Australia for each quarter hour of the day and night for use by commercial advertisers —this is now a continuous job.

3. Extensive astronomical calculations covering both optical and radio astronomy, mainly for C.S.I.R.O. (Commonwealth Scientific and Industrial Research Organization) and the Government Astronomer.

4. The molecular structure of very complex organic compounds for the Division of Industrial Chemistry, C.S.I.R.O., Melbourne.

5. The behaviour of catchment areas and dam storage systems in Australia for a drought and flood investigation for the Department of Meteorology.

6. Simulation of the New Warragamba Dam for the Electricity Commission and the Metropolitan Water, Sewerage & Drainage Board.

7. A study of fluctuations in the South Pacific ocean level.

8. A study of the unusual wave patterns in Coff's Harbour and Port Kembla on the New South Wales coast which are a problem to moored ships. This study is related to the investigation made by T. S. Walton and H. Polachek ("Mathematics of Computation," January 1960, Volume 14, page 27) on the calculation of transient motion of submerged cables for ships used in Pacific atomic tests.

Current projects include:

1. An extensive weather study and upper wind correlations over Australia for the Commonwealth Bureau of Meteorology.

2. A separate study of dynamic weather forecasting by computer methods being done by the Meteorology Department of Melbourne University.

3. A very large data sorting problem for Brisbane (Queensland) City Council. This is the processing of an origin and destination survey for the future planning of Brisbane traffic, new roads, new shopping centres, motels, and the location of new commercial buildings for the next twenty years.

4. A study of air traffic in Australia with a view of improving same for the Department of Civil Aviation.

5. An operations research problem on the planning of new telephone exchanges in Sydney. This is a non-linear programming problem and a new technique has been developed to condense the size of the initial problem by a factor of 16.

Current staff research projects include numerical techniques for study of the behavior of parametric amplifiers, the treatment of non-linear difference-differential equations occurring in the flutter of compressor blades in jet engines, some aspects of the design of a new long range missile nose cone. In addition, students doing their Master of Engineering and Science degrees under the supervision of the laboratory are working on high frequency electromagnetic levitation of metals, stability analysis of helicopter operation and new techniques for the biharmonic equation in civil engineering with an aim to producing a high speed computer programme.

ELEA 9003 - C. OLIVETTI & C. - MILAN, ITALY

The electronic computer ELEA 9003 is a complete system composed of a series of units which prepare a large volume of data to be processed, perform automatically any mathematical or logical operation and provide, at high speed, the results in the form required for their direct use or filing.

The ELEA 9003 system includes both on-line and off-line equipment. The connection of the on-line equipment to the central processing unit is done in such a way as to provide maximum use of the connected machinery, and minimum interference with the main running program. These characteristics are achieved by individual buffering for every on-line machine, and multisequential programming in the central unit.

The on-line equipment can therefore operate independently, following the instructions of the central unit, and perform simultaneous operations, thus reducing processing times. The connection between the components of the central unit through two different transfer channels makes this procedure possible. Basically, the internal channel connects the high-speed storage to the arithmetic and logical unit, the control unit, and the synchronizer of on-line input-output units. The external channel, on the other hand, connects the high speed storage to the magnetic tape and magnetic drum control units. Tapes and drums are so important in a large scale system that in most applications the external channel is fully occupied by these units. However, in the few instances when the program does not require magnetic tapes or drums, the external channel can be used for internal operations or transfers between any two zones of the main core storage with the result of doubling the internal operating speed.

The system, can perform simultaneously several program instructions involving different units; e.g., internal channel, external channel, magnetic tape control, on-line input and output units.

For instance it can perform simultaneously: An arithmetic or internal transfer operation, a read or write on magnetic drum, an independent tape-search, one or more magnetic tape rewinds, one or more input or output operations, a print operation by the means of the enquiry station.

The ability to perform up to three parallel Program Sequences makes it possible to take full advantage of these simultaneous operations. The three program-sequences can start simultaneously and are performed in accordance with an automatic priority processing. The feature, of course, is used only when the same unit is required simultaneously by two programs. A typical application of the three program-sequences is the following: The first stores the instructions concerning the components of the central unit, the second stores the instructions concerning the magnetic tape and magnetic drum units, while the third holds the instructions concerning the on-line input or output units.

The instruction repertoire contains 88 instructions for normal arithmetic operations, logical operations, comparisons, character transfers between high speed storage zones, single bit operations, handling of constants, branching both on external or internal conditions, jump, independent tape-search, and a large group of logical commands.

The single address instruction consists of four parts: The first defines the operation function (F), the second gives the initial storage address of the item to be processed (AAAA), the third indicates the word length (LL), and the fourth identifies the register for automatic address modification (R). The instruction can thus be represented as follows:

LL   AAAA   R   F

For example, an instruction referring to a 12 digits number stored in the memory at the initial address 2782 will be coded:

12   2782   R   F

When the word length is unknown, it is possible to write the instructions in the following form:

2782   R   F

In this case, the entire group of characters included between the initial address and the next comma will be processed. If all stored items are separated by a comma this kind of instruction gives the possibility of programming with words of unknown length. The instructions can be stored anywhere in the high speed memory; each location can in fact store either program instructions or data.

The central unit consist of two components: The general purpose digital computer or central unit, and the magnetic tape control. The digital computer consists of the following parts:

Fast-access Magnetic Core Storage. Each character is represented by six bits operating in parallel. Consequently $2^6 = 64$ alphanumeric characters are possible. Core storage capacity ranges from 20,000 up to 160,000 characters. The single character addressing allows the most advantageous use of storage capacity. The transfer time for two characters (14 bits), including restoring time is 10 microseconds.

Arithmetic and Logical Unit. This unit performs arithmetic computations, comparisons and logical operations, modifies program instructions, and helps the information transfer. The unit includes an arithmetic operator, a check which verifies the operations by means of a modulo 3 check, and a compare indicator or accumulator. The arithmetic and logical unit can handle both numerical and alphabetic information.

Accumulator. Normal function is to hold one of the operands and successively the results. If required it can also serve as an auxiliary storage. The accumulator consists of a magnetic core storage with a capacity of 100 alphanumeric characters plus sign, with a single character address.

Program Modification Registers. There are 40 registers for automatic program modification. These consist of a magnetic core memory with a capacity of 200 alphanumeric characters, which can be addressed in blocks of 5 positions. Their main function is to store constants which permit automatic program modification to the arithmetic and logical unit. If required, these registers can also perform arithmetic computations and logical operations or comparisons.

Central Unit Checking. The central unit is provided with three different built-in checking features: Odd-checking of each character transfer between high speed storage, accumulator, and registers; modulo 3 check, which verifies the accuracy of arithmetic operations, and transfers from storage to registers and accumulator; indicator of non numerical representations, which allows a further checking of arithmetic and transfer operations. This last type of check is possible because certain binary representations do not occur in numerical characters. These checking features are applied to transfer on both data flow channels and to each arithmetic operation.

The magnetic tape system consists of tape control which coordinates the various tape operations performed either in connection with the computer control or independently, and a variable number of tape units. Instructions may be classified in two groups. The first includes instructions whose execution also involve the control unit: Tape read and transfer to storage, simultaneous tape read and write, and tape read and write from or to a single storage location. The second include those instructions whose execution is independent of the control unit: Simultaneous tape rewind of all tape units, tape duplication, forward or reverse tape drive for a specified length in inches, and tape search with possible simultaneous transcription of the information on other tape.

Reliability of tape operations is provided by an odd-check. An additional check during write operations is that the information written by a magnetic head is immediately read by a second head and compared with the original information stored in a special core storage.

The tape control can connect up to 20 magnetic tape units. These tape units permit a read-write rate of 45,000 alphanumeric characters per second. Characters on tape are coded with the same binary representation used in the high speed storage. The 1/2 inch oxide-coated magnetic tape can store up to 12,800,000 characters with a packing density of 300 characters per inch. End of tape sensing, plus a write-lock-out that locks out the write function preventing possible destruction of records during read, guarantees the highest safety of operation. Furthermore, each unit is provided with the following automatic indicator signals: Automatic ready signal indicates that "mode" selector is in Auto position, warmup is completed, and safety interlock system is fully activated; long-short loop signal indicates when tape loop has expanded or contracted beyond normal size; and manual write signal indicates

that the "mode" selector is in Manual and the "Leader drive-Manual write" Selector is in Manual-Write. This signal may be used with Write Lockout control.

Up to three magnetic drums can be connected to the 9003 system. Each drum provides an auxiliary storage of 120,000 alphanumeric characters. Characters are stored in 64 parallel tracks. Each character within the track can be individually addressed in read or write operations. Waiting time for drum operations averages 10 milliseconds. Information is transferred at the rate of 90,000 characters per second. The information length can vary from one character to the total track capacity of 1920 characters. Magnetic drums are connected with the computer by means of a control unit which selects the drum, the track, and the address indicated in the instruction.

The Synchronizer coordinates the operations of the various input-output units, and provides their simultaneous and semi-independent running together with other tape or high-speed storage operations. Any possible combination of the following units, within a maximum of ten, can be controlled by the synchronizer:

Card reader (500 cards per minute)
Card punch (150 cards per minute)
Paper tape reader (6-channel, square hole paper, 800 characters per second)
Paper tape punch (150 characters per second)
Parallel Printer (300 lines per minute. The print device consists of 102 wheels with 36 characters per wheel).

Special buffer storages provide transfer between these "on line" units and the high-speed memory. The 9003 is an flexible data processing systems which can operate with all kinds of input-output units; thus in addition to those mentioned above, random access memories, documents readers, and other devices can be connected.

The following conversion units can increase the processing capacity of the system by performing various "off line" operations: Card to magnetic tape converter (700 cards per minute); punched tape to magnetic tape converter (800 characters per second); magnetic tape to print converter (600 alphanumeric or 1000 numeric lines per minute. The printer consists of 120 wheels with 56 characters per wheel); magnetic tape to card converter (150 cards per minute).

Programming ease and speed is enormously increased by two automatic compiler programs respectively adaptable to commercial or scientific problems.

The cabling system connecting the various ELEA 9003 units is completely overhead thus requiring no expense for sub-floor installation. All transistorized circuit logic permits compact size, low heat dissipation, and low power consumption.

COMPONENTS

PNEUMATIC COMPUTER COMPONENT
DIAMOND ORDNANCE FUZE LABORATORIES - WASHINGTON, D.C.

The Army's Diamond Ordnance Fuze Laboratories have invented a family of control devices which use gas or liquids instead of electric current to operate the units and which have no moving parts. Consisting simply of a block of metal or heavy plastic material in which passageways have been made, these units can perform the same complicated functions of complex electronic circuits in a computer or control device. DOFL has already successfully developed units which can perform amplification, feedback, digital computation, analog computation, normal mathematic functions, and memory. It appears that their system of pure pneumatics, using gas or liquids as the energy force to operate the units, may have wide spread applications in both military equipment and in industrial usage.

The basic building block of the fluid-actuated systems—which use no moving parts—is the amplifying element, i.e., the "pure fluid amplifier," just as the vacuum tube and transistor constitute the basic building blocks of electronic systems. Fluid amplification with the aid of moving parts is already very widely used and systems using this type of amplification are very well developed. For example, the sliding valve on a steam locomotive is a fluid amplifier. Pure fluid amplifiers accomplish amplification without moving parts. The basic idea of a pure fluid amplifier is to direct a low power stream of fluid against the side of a high power stream. The low power stream, which we call the "control stream," is used to displace or redirect the "power stream," i.e., the control stream tells the power stream where to deliver its energy. If the power stream can be controlled by a lower power level than that of the power stream, the device may properly be called an amplifier. Since it is done without the use of moving parts, it can be called a pure fluid amplifier.

Using the above principles and other closely related effects, a whole new class of amplifiers, computers, logic circuits, and control systems is possible. One of the most attractive features of a fluid-actuated system without moving parts is its ruggedness. It consists only of a solid having appropriate passages and a fluid. The inherent simplicity should make it extremely reliable. Another attractive feature of a pure fluid computer is its low cost. In comparison with other types of computing elements these units will be extremely cheap.

The capacity of a pure fluid amplifier for high temperature operation undoubtedly goes far beyond that of any other known amplifying action, since the operation depends only upon the shape of a solid and the flow properties of a fluid. A properly designed unit could operate at white heat if a refractory material is used for the body, and a stable, non-corrosive gas is used as the fluid.

An important limitation of fluid-actuated systems is speed. They will never compete with electronic systems for the very high speed applications, but are much faster than fluid systems with moving parts, and their speed is entirely adequate for many applications, both military and industrial. Their speed of response is adequate for handling signals in the audio frequency band.

MISCELLANEOUS

COMPUTING LABORATORY - BALLISTIC RESEARCH LABORATORIES - ABERDEEN PROVING GROUND, MARYLAND

In 1955, and again in 1957, the Ballistic Research Laboratories distributed a report of surveys of domestic electronic digital computing and data processing systems. Over 5,000 copies were distributed by the Ordnance Corps, and Office of Technical Services, U. S. Department of Commerce, as BRL Report 1010 and Public Bulletin 111996, and PB 111996R. Many comments were received indicating that the reports provided valuable information which was of specific use in making decisions concerning the acquisition, installation, operation, improvement, and retirement of computing systems.

The Army, Navy and Air Force, and their contractors have become interested in the results of these surveys, and consequently the Department of Defense has requested that a third survey be made. Anyone who is manufacturing or operating digital computer equipment who has not already been contacted by the BRL in regard to the new survey should notify:

> Mr. Martin H. Weik
> Editor, Computer Survey
> Computing Laboratory, BRL
> Aberdeen Proving Ground, Maryland

BRL welcomes any inquiries concerning this survey. Comments, suggestions, references, to other sources, and any additional technical data will be appreciated.

CONTRIBUTIONS FOR DIGITAL COMPUTER NEWSLETTER

The Office of Naval Research welcomes contributions to the NEWSLETTER. Your contributions will assist in improving the contents of this newsletter, and in making it an even better medium of exchange of information, between government laboratories, academic institutions, and industry. It is hoped that the readers will participate to an even greater extent than in the past in transmitting technical material and suggestions to this Office for future issues. Because of limited time and personnel, it is often impossible for the editor to acknowledge individually all material which has been sent to this Office for publication.

The NEWSLETTER is published four times a year on the first of January, April, July, and October, and material should be in the hands of the editor at least one month before the publication date in order to be included in that issue.

The NEWSLETTER is circulated to all interested military and government agencies, and the contractors of the Federal Government. In addition, it is being reprinted in the Communications of the Association for Computing Machinery.

Communications should be addressed to:

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> Office of Naval Research
> Washington 25, D. C.

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